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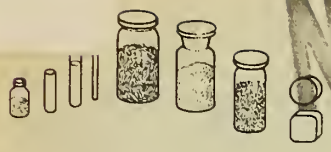

Standard Reference Materials:

HALF LIVES OF MATERIALS USED IN THE PREPARATION OF STANDARD REFERENCE MATERIALS OF NINETEEN RADIOACTIVE NUCLIDES ISSUED BY THE NATIONAL BUREAU OF STANDARDS

U.S. Department of Commerce

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Standard Reference Materials:

Half Lives of Materials Used in the Preparation of Standard Reference Materials of Nineteen Radioactive Nuclides Issued by the National Bureau of Standards

S. C. Anspach, L. M. Cavallo, S. B. Garfinkel, J. M. R. Hutchinson, and C. N. Smith

Institute for Basic Standards
National Bureau of Standards
Washington, D.C.

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PREFACE

Within the frame work of the National Bureau of Standards Institutes the area of standard reference materials is a broad and important one, including the preparation, characterization and distribution of a wide variety of materials in such diverse fields as metallurgy, polymers and inorganic materials. In carrying out such a program there is much interaction with representatives of industry and science, beginning with discussions as to which primary standard materials will do most to advance technology, the furnishing of materials and fabrication of samples, and the characterization and certification of the materials by cooperative efforts. The many groups participating in a standards program are very interested in detailed information on specific aspects of the program -- but to date there has been no publication outlet for such written discussions.

To meet this need, NBS Miscellaneous Publication 260 has been reserved for a series of papers in the general area of "standard reference materials". This subject-oriented series will provide a means for rapid dissemination of this detailed information and we hope will stimulate the use of standard reference materials in science and industry.

W. Wayne Meinke, Chief
Office of Standard Reference
Materials

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OTHER NBS PUBLICATIONS IN THIS SERIES

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STANDARD REFERENCE MATERIALS: HALF LIVES OF MATERIALS USED IN THE PREPARATION OF STANDARD REFERENCE MATERIALS OF NINETEEN RADIOACTIVE NUCLIDES ISSUED BY THE NATIONAL BUREAU OF STANDARDS

S. C. Anspach, L. M. Cavallo, S. B. Garfinkel,
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ABSTRACT

Values are given for the half lives of materials used in the preparation of standard samples of Na^{22}, Ca^{45}, Sc^{46}, Mn^{54}, Co^{57}, Co^{60}, Zn^{65}, Kr^{85}, Sr^{85}, Sr^{89}, Sr^{90}, Y^{88}, Nb^{95}, I^{125}, Ce^{139}, Ce^{141}, Pm^{147}, Hg^{203}, Tl^{204}, issued by the National Bureau of Standards. Instrumentation, source preparation, and the determination of impurities are also discussed.

Key Words: Half lives, calcium-45, cerium-139, cerium-141, cobalt-57, cobalt-60, iodine-125, krypton-85, manganese-54, mercury-203, niobium-95, promethium-147, scandium-46, sodium-22, strontium-85, strontium-89, strontium-90, thallium-204, yttrium-88 and zinc-65.

For many years, members of the Radioactivity Section of the National Bureau of Standards have followed the half lives of sources prepared from the same materials used in the preparation of standard samples of radionuclides for distribution. The results of this program have not previously been published, and in view of the widespread distribution of these standards, and the large spread in the reported values of the half lives of many of the radionuclides involved, these results are being presented so that appropriate decay corrections may be applied by users of these standards.

In most cases the purified radioactive material was obtained from commercial sources or Oak Ridge National Laboratory. In some cases, further purification was made in this laboratory, or the material was examined spectrometrically for impurities. When information on the radioactive purity is available, it is given. However, the extent to which the logarithmic plot of the measured activity, over an extended period of time, approximates a straight line is taken as an indication of the radioactive purity.

The instruments used in these determinations were the National Bureau of Standards $4\pi\gamma$ ionization chamber, the National Bureau of Standards $2\pi\beta$ ionization chamber, and the National Bureau of Standards $4\pi\beta$ flow proportional counter, all described in NBS Circular No. 594. The determinations consist of individual observations made at convenient time intervals. The half lives and their standard errors were calculated from the straight line fitted to the data by the method of least squares. In some determinations, measurements were made on several

sources from the same material. The value of the half life and the standard error associated with it were computed for each source separately. Each value was then weighted with its error and the weighted average reported. The error reported was computed using the formula:

$$\frac{1}{\sigma} = \sqrt{\left\{\frac{1}{\sigma_1}\right\}^2 + \left\{\frac{1}{\sigma_2}\right\}^2 + \text{-----} \left\{\frac{1}{\sigma_n}\right\}^2}$$

With the exception of krypton-85, sources for the $4\pi\gamma$ ionization chamber were 5 milliliters of radioactive solution, flame-sealed in glass ampoules. The krypton-85 source was approximately 30 mc of gas in a break-seal glass ampoule. Each source was compared with a radium-226 reference source, the ratio of the activity of the source under investigation to that of the radium-226 source constituting one observation. Corrections (if significant) were made for the decay of radium-226, using a half-life value of 1622 years. The temperature and pressure were carefully monitored during each measurement and appropriate corrections made for changes in air density.

Sources for the $2\pi\beta$ ionization chamber were made by imbedding the radioactive material in epoxy resins mounted in aluminum holders. These were compared with either a radium-226 or a cesium-137 reference source. A half life of 29.5 years was assumed for the Cs^{137} reference source.

Sources for the $4\pi\beta$ proportional counter were prepared by depositing aliquots of radioactive solutions on thin plastic films ($\sim 4\mu g/cm^2$ to 25 $\mu g/cm^2$ thick) which had either electrically conducting coatings of gold ($\sim$ 20 $\mu g/cm^2$) evaporated on them, or aluminum leaf backings ($\sim$ 220 $\mu g/cm^2$). The aliquots of solution were dried and then covered with films identical to the supporting ones to produce a symmetrical sandwich. The sources were counted in the $4\pi\beta$ proportional counter, the counts per second at a given time constituting one observation. The 4π geometry and the stability of the instrument made measurement of a reference source unnecessary. The dead time of the counting system was checked periodically and small corrections were made.

The material used in the determination of the half lives of Sc^{46}, Mn^{54}, Co^{57}, Sr^{85}, Y^{88}, Ce^{139}, Hg^{203}, and the Zn^{65} issued after 1959, were examined in this laboratory for gamma-ray impurities with a NaI(Tl) scintillation spectrometer at the time of the initial measurement. Approximately 10^4 counts in the full-energy peak (or peaks) characteristic of the radionuclide under investigation were collected. No other peaks greater than 0.1% of this value, were observed.

In the case of the Mn^{54} (4997 series), an iron-55 contaminant was removed chemically prior to the standardization. It was estimated that there was less than 0.1% iron-55 remaining.

The Sr^{89} material was examined with both a NaI(Tl) scintillation spectrometer and a beta-ray anthracene scintillation spectrometer at the time of the initial and final half-life measurements. The Sr^{85}

disintegration rate was found to be 0.096% of the Sr^{89} initially, with about 30% of this being detected in the $4\pi\beta$ counter as compared with 99% of the Sr^{89}. The Sr^{90}-Y^{90} disintegration rate was found to be less than 0.02% of the Sr^{89} initially, the Sr^{90}-Y^{90} having the same efficiency as the Sr^{89}. The contribution of these contaminants was considered to be insignificant and no corrections were made for them.

A cesium-137-barium-137m impurity in the I^{125} (4944 series) was detected spectrometrically and found to have a disintegration rate approximately 0.015% that of the I^{125} on the date of issue. The source used for the half-life measurement was, therefore, remeasured 428 days after the final half-life measurement. The activity due to iodine-125 still present was calculated, using a 60-day half life, and subtracted from the measured activity. The remaining activity was assumed to be due to the cesium-137-barium-137m impurity and was subtracted from the half-life data used to determine the value given in Table 1 for iodine-125.

Similarly, the contribution of a cerium-144-praseodymium-144 contaminant, which was observed spectrometrically in the Ce^{141}(4946 series), was determined from a measurement of the half-life source 260 days after the final half-life observation, and was subtracted from the data used to determine the value shown in Table 1 for cerium-141. The disintegration rate of the cerium-144-praseodymium-144 contaminant was computed to be approximately 0.64% of that from the Ce^{141} on the date of issue of the 4946 series.

A list of references to some of the more recently published values for the half lives of the radionuclides appearing in Table 1, is given here.

Table 1

Nuclide	Half Life	Standard Error	No. of Observations	Number of Half Lives Measured	Standard Sample Number	Date Issued	Instrument Used*	No. of Sources per Batch
Na^{22}	2.591y	0.003y	56	2.6	4921	10-14-54	$4\pi\gamma$	2
	2.613y	0.011y	13	.5	4922-B	4-29-59	"	1
	2.603y	0.001y	29	1.2	4921-B 12-11-61 4922-C 12-11-61		"	1
	2.602y	0.011y	11	.5	4922-D	6-30-64	"	1
Ca^{45}	162.63d	0.11d	46	5.8	4942	2-1-62	$4\pi\beta$	4
Sc^{46}	83.80d	0.03d	24	2.8	4939	7-20-60	$4\pi\gamma$	1
Mn^{54}	311.9d	0.2d	26	1.3	4997	9-1-60	$4\pi\gamma$	1
	311.9d	0.2d	16	1.5	4997-B 7-24-61 4997-C 3-1-62		"	1
	312.6d	0.4d	14	1.6	4997-D	10-22-63	"	1
Co^{57}	271.65d	0.13d	27	2.1	4941	12-19-61	$4\pi\gamma$	1
Co^{60}	5.242y	0.008y	34	1	4914 4915	7-24-47	$4\pi\gamma$	1
					4914-A 4915-A	10-1-53		
Zn^{65}	243.1d	0.7d	44	3.1	4930	3-1-57	$4\pi\gamma$	3
	244.12d	0.12d	50	2.1	4930-B	3-11-60	"	2
	242.78d	0.19d	18	2.1	4930-C 8-2-61 4930-D 1-7-62		"	1
Kr^{85}	10.75y	0.03y	24	.59	4935 4935-A	12-10-57	$4\pi\gamma$	1
Sr^{85}	65.19d	0.13d	6	1.4	4938	8-24-59	$4\pi\gamma$	1
Y^{88}	106.52d	0.03d	19	2.6	4998	9-10-61	$4\pi\gamma$	1
	106.67d	0.03d	18	2.7	4998-C	3-12-65	"	1

Table 1 Continued

Nuclide	Half Life	Standard Error	No. of Observations	Number of Half Lives Measured	Standard Sample Number	Date Issued	Instrument Used	No. of Sources per Batch
Sr^{89}	50.70d	0.19d	8	1.8	4945	12-5-63	$2\pi\beta$[i]	1
	50.52d	0.03d	62	5.1	4945-B	9-1-64	$4\pi\beta$	4
Sr^{90}	28.82y	0.14y	69	.39	4919	4-15-53	$4\pi\beta$	6
					4919-B	4-6-57		
I^{125}	59.83d	0.11d	20	3.3	4944	12-19-62	$2\pi\beta$[ii]	1
Ce^{139}	137.5d	0.3d	9	1.2	4999	1-1-63	$4\pi\gamma$	1
Ce^{141}	32.55d	0.007d	30	5.2	4946	1-3-64	$4\pi\gamma$	1
Pm^{147}	2.618y	0.007y	33	1.3	4940	5-1-61	$4\pi\beta$	2
					4940-B			
Hg^{203}	46.56d	0.02d	9	4.8	4932	3-12-59	$4\pi\gamma$	1
	46.577d	0.008d	18	5.1	4932-C	5-28-64	$4\pi\gamma$	1
Tl^{204}	3.754y	0.004y	53	1.9	4920-B	6-7-57	$4\pi\beta$	2

* $4\pi\gamma$ - $4\pi\gamma$ ionization chamber
$4\pi\beta$ - $4\pi\beta$ proportional counter
$2\pi\beta$ - $2\pi\beta$ ionization chamber

[i] The Sr^{89} source was compared with a Cs^{137} reference source as a Ra^{226} reference of comparable intensity was not available.

[ii] The I^{125} source was compared with a Ra^{226} reference source.

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	(165.1±0.7)d	E. I. Wyatt, et al, Nuclear Sci. and Eng. 11, 74 (1961)
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Co^{60}	(5.24±0.03)y	K. W. Geiger, Phys. Rev. 105, 1539 (1957)
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Sr^{89}	(50.36±0.18)d	R. G. Osmond, M. J. Owers, J. Inorg. Nuclear Chem. 9, 96 (1959)
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